Latest results ot the EDELWEISS experiment :

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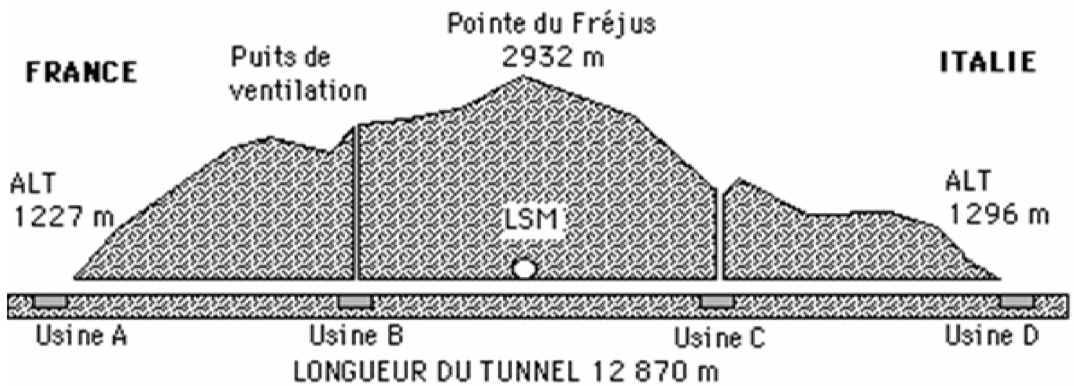
EDELWEISS : Dark Matter search experiment

- Astronomical observations gives :

$$\Omega_{mat} \sim 0.3$$
$$\Omega_{baryonic} \sim 0.04$$
$$\Omega_{lum} \sim 0.003$$

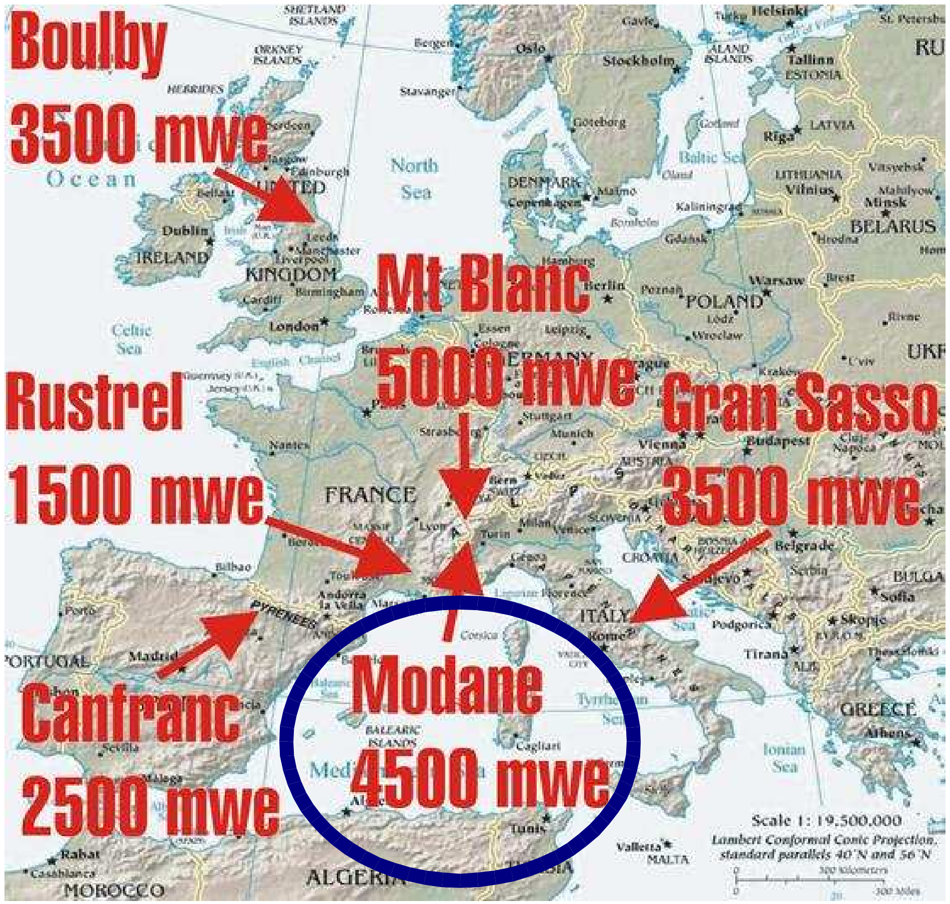
- Most of the matter in the Universe is dark
- Only a small fraction of it is baryonic
- Non baryonic candidate :
  - WIMP : Weakly Interacting Massive Particle
  - In the framework of the MSSM, WIMP corresponds to the neutralino (LSP)

EDELWEISS : Frejus Underground Laboratory

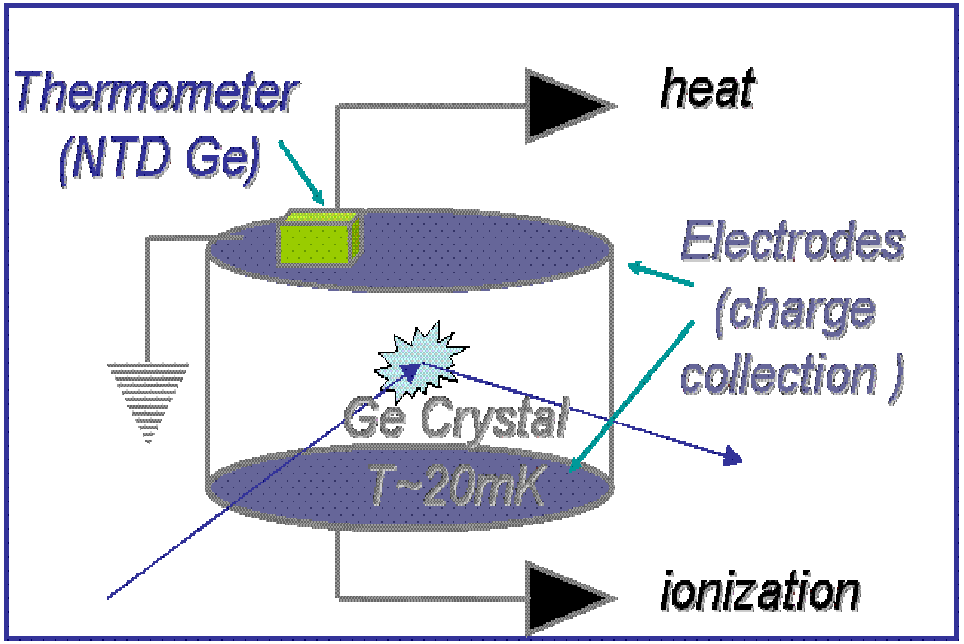


- Low event rate :
  - Passive shielding
  - Underground site
- Under 1700m rock
- Muon flux : 4 /m²/d
- Rock radioactivity :

1.6×10^{-6} n/cm²/s

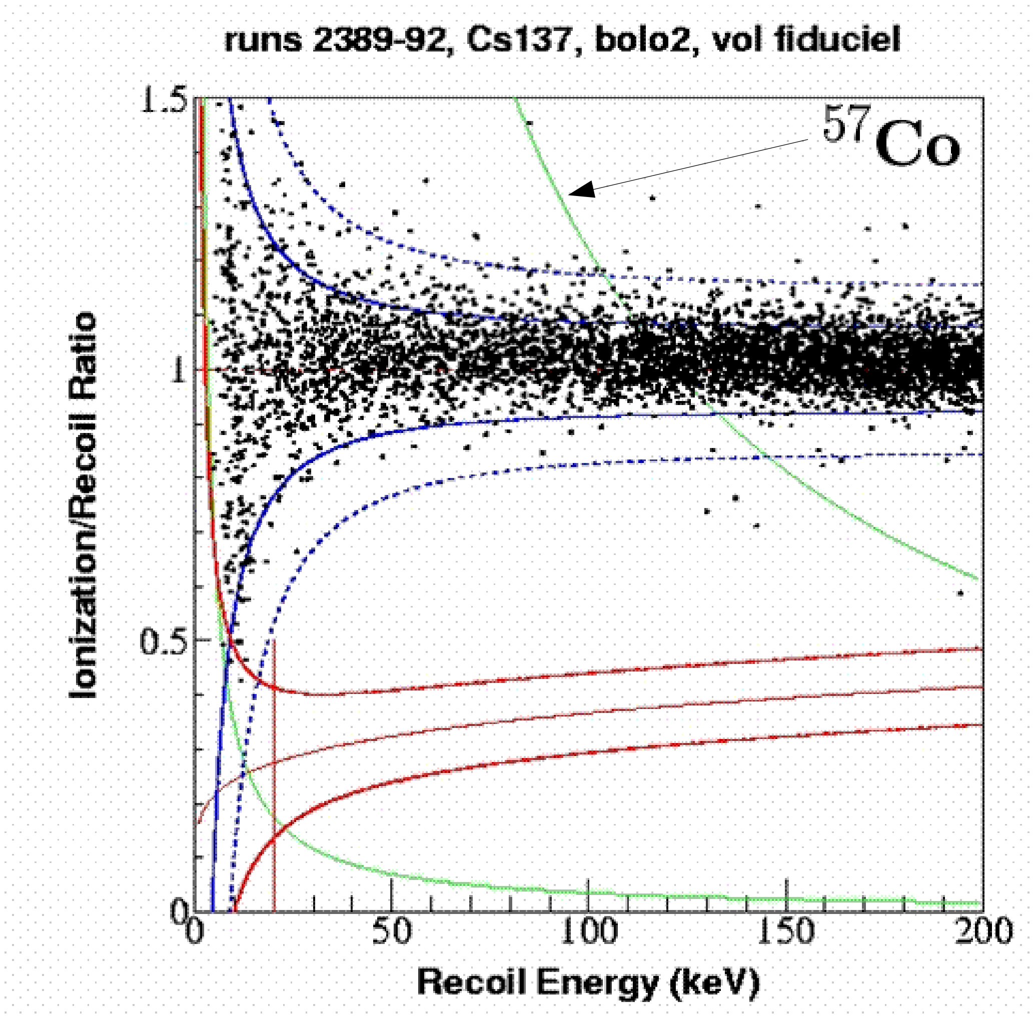


Ionisation-heat cryogenic detectors
Event by event discrimination



- Measurement of heat :
  - Why cryogenic ? :
    $$\Delta T = \frac{\Delta E}{C}\ ,\ C \propto T^3$$
  - Need to have C small
- Measurement of ionisation :
  - Semiconductor Germanium
  - Charge collection by detector polarisation
- Different charge/heat ratio for nuclear recoils and electronic recoils
- Simultaneous measurement for each interaction

GGA1 : Gamma Calibration



GGA1 : Neutron Calibration

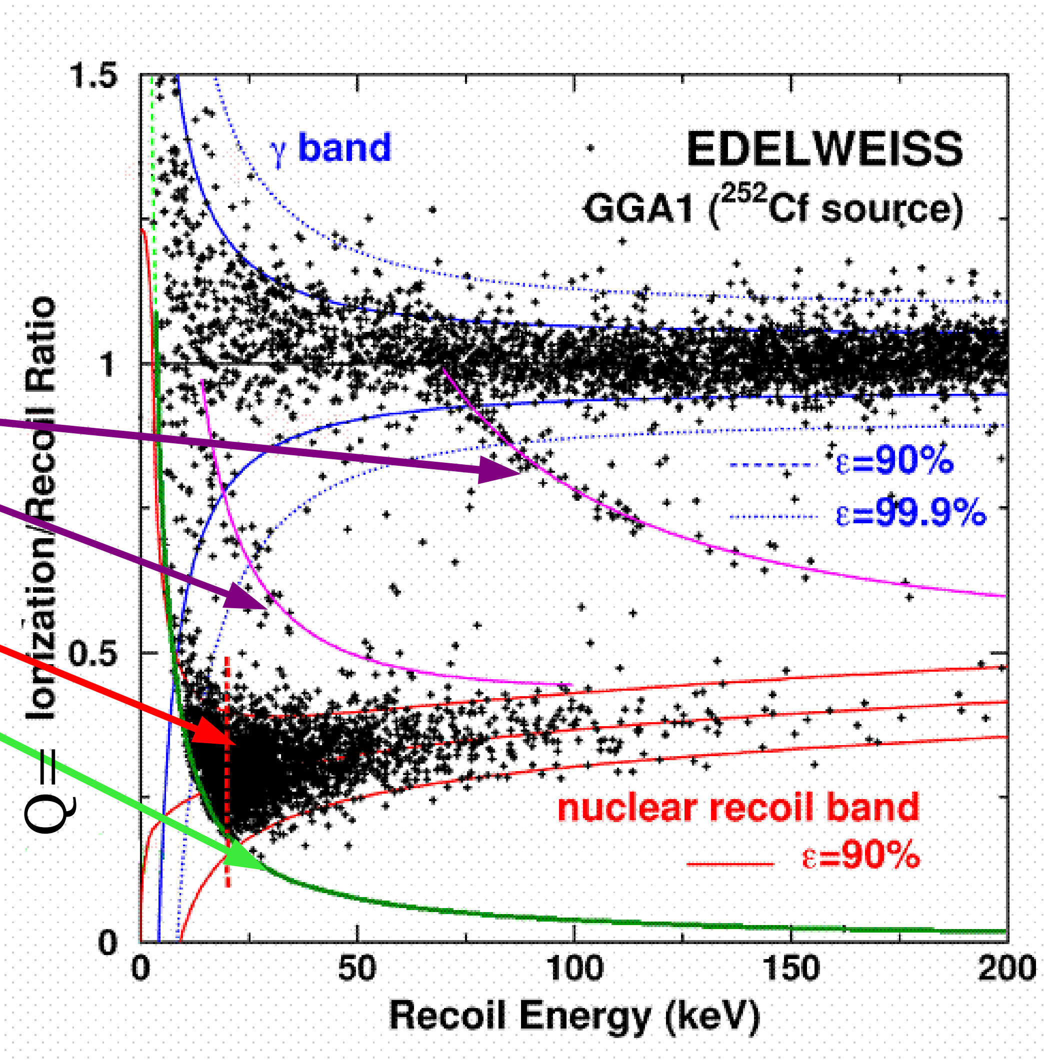
Discrimination n/gamma
> 99.9 % for Er>15 keV

$^{73}\mathbf{Ge}(n, n'\gamma)$

Recoil threshold: 20 keV

Ionisation threshold : 3.7 keV

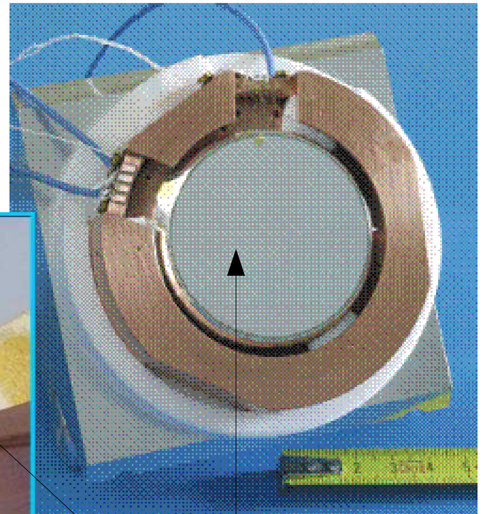
Event-by-event discrimination
down to
thresold energy



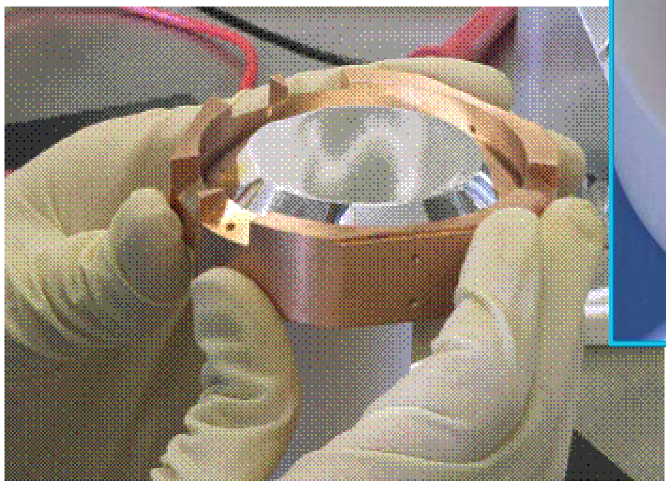
EDELWEISS detectors

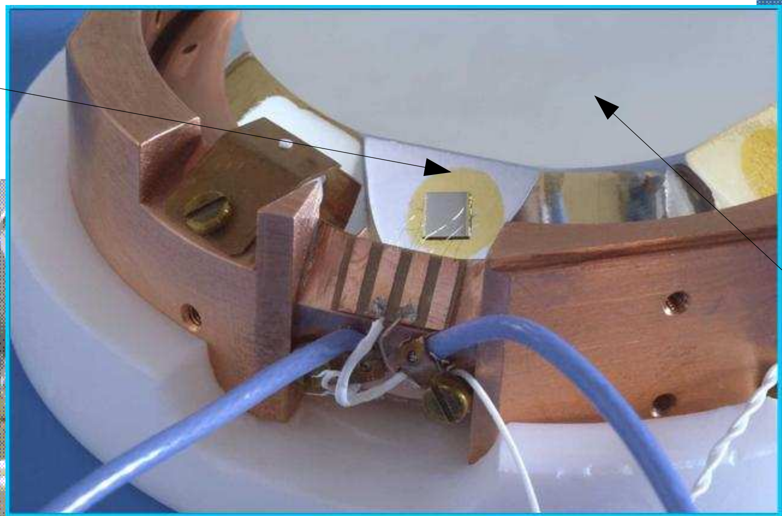
- 1st data taking: Fall 2000
- 2nd data taking: 1st semester 2002
- 3rd data taking :October 2002-March 2003

Bottom view



Heat sensor NTD



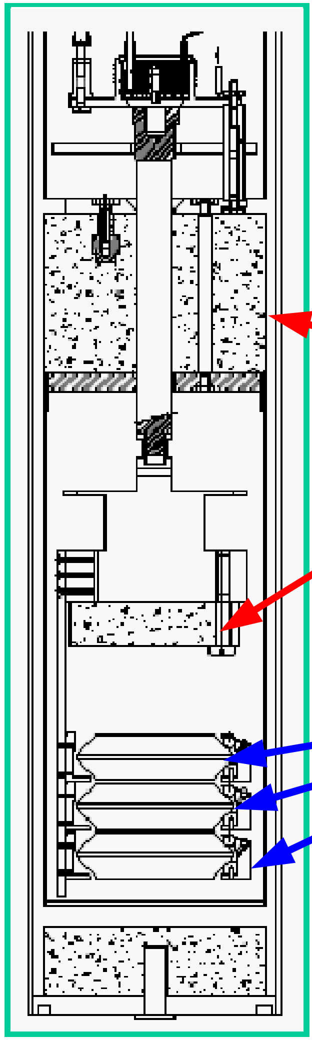


Top view

Al sputtered electrodes

- Guard ring
- Ge or Si amorphous layer

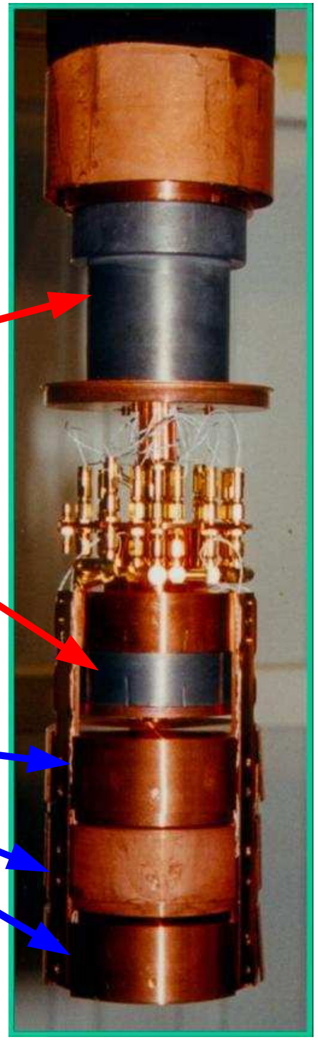
1 kg stage of EDELWEISS I



•Shield : 30 cm de paraffin
20 cm lead
10 cm copper

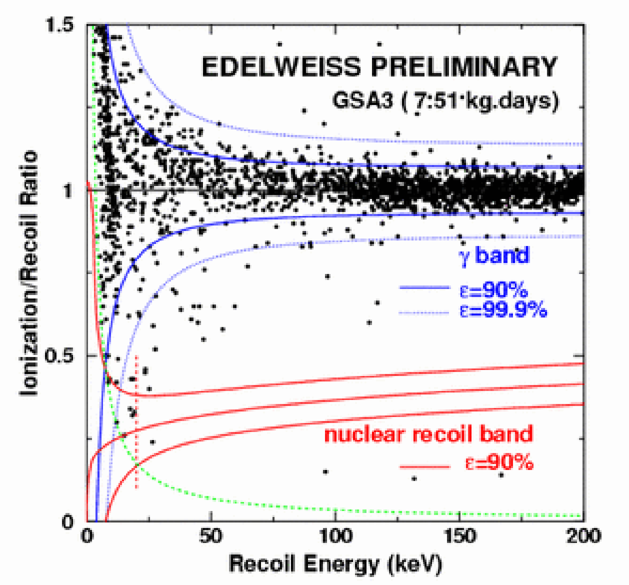
Roman Lead

3×320g
Germanium
Detectors



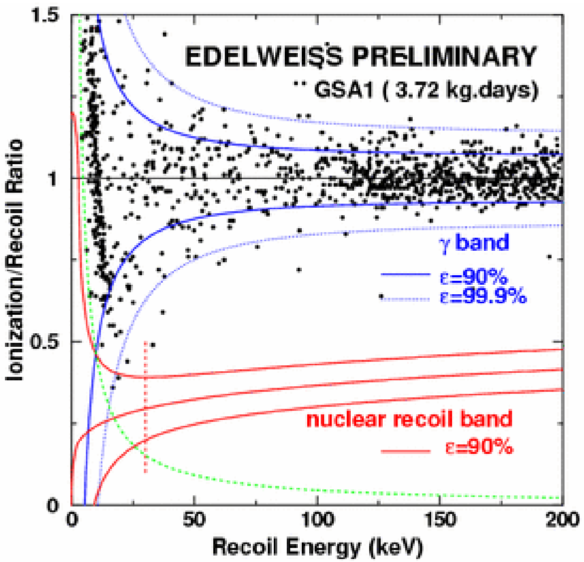
New data : Q=f(Er) diagrams

Bolometer 1



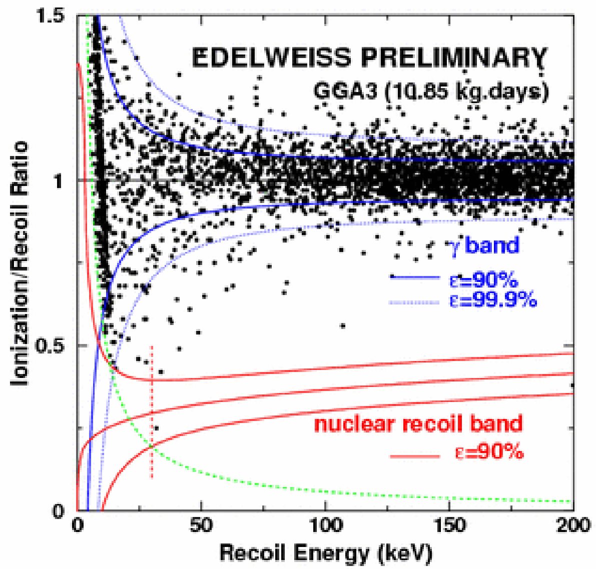
- 7.51 kg.d exposure (fiducial volume)
- Best charge channel : 1 keV (FWHM)
- 20 keV threshold

Bolometer 2



- 3.72 kg.d (fiducial)
- Smaller exposure due to electronics problems
- 30 keV threshold

Bolometer 3



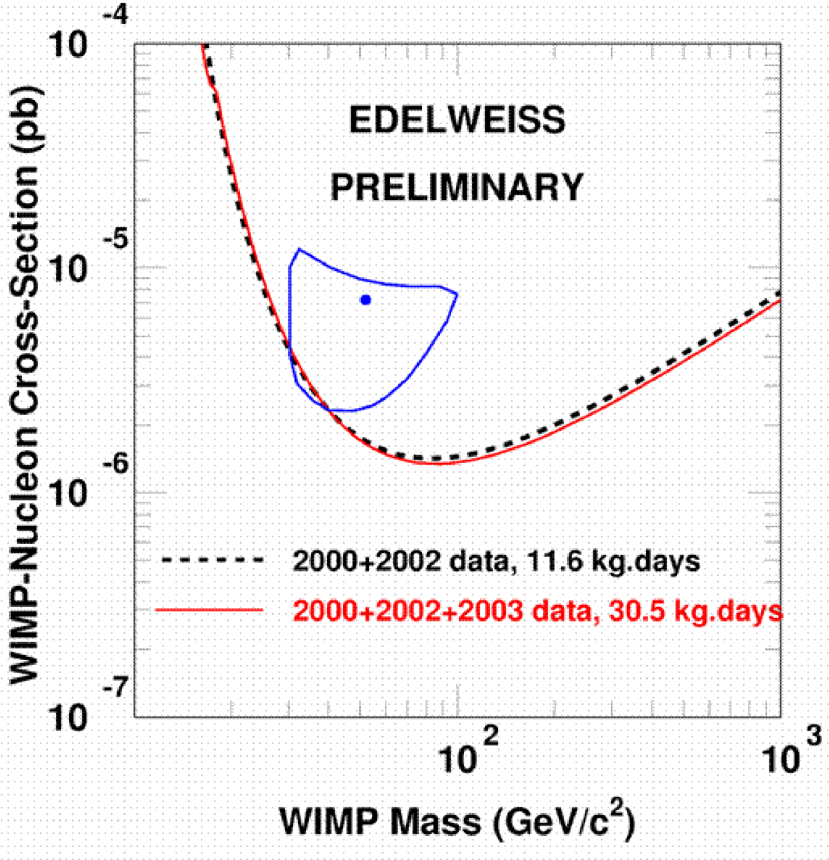
- 10.86 kg.d (fiducial)
- Good phonon channel 300 eV (FWHM) resolution during most of the runs
- Noisy charge channel
- 30 keV threshold

EDELWEISS new limits

- No background subtraction

Data 2000+2002 : Benoit et al., Phys. Let. B 545 (2002) 43-49

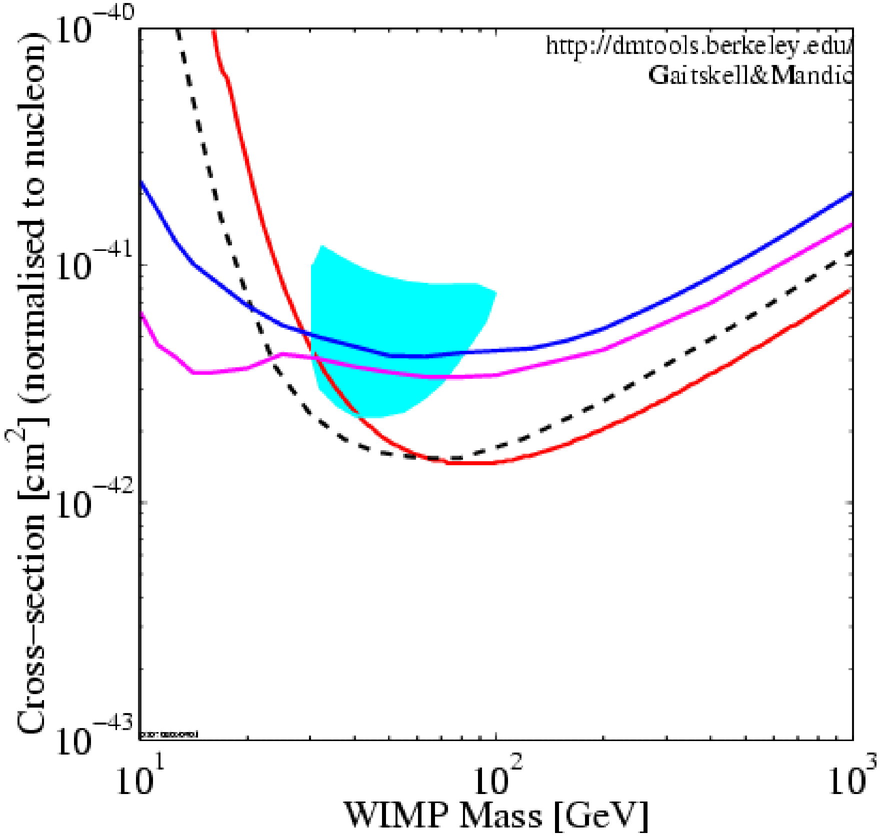
- DAMA best fit exclusion at > 99.99 % C.L. confirmed with 3 new detectors and 20 kg.d additional exposure
- Exclusion is astrophysical model independent



Copi et Krauss :

Phys. Rev. D67 (2003) 103507

Comparison with other direct detection experiments



CDMS no background subtraction hep-ex/0306001

CDMS with background subtraction hep-ex/0306001

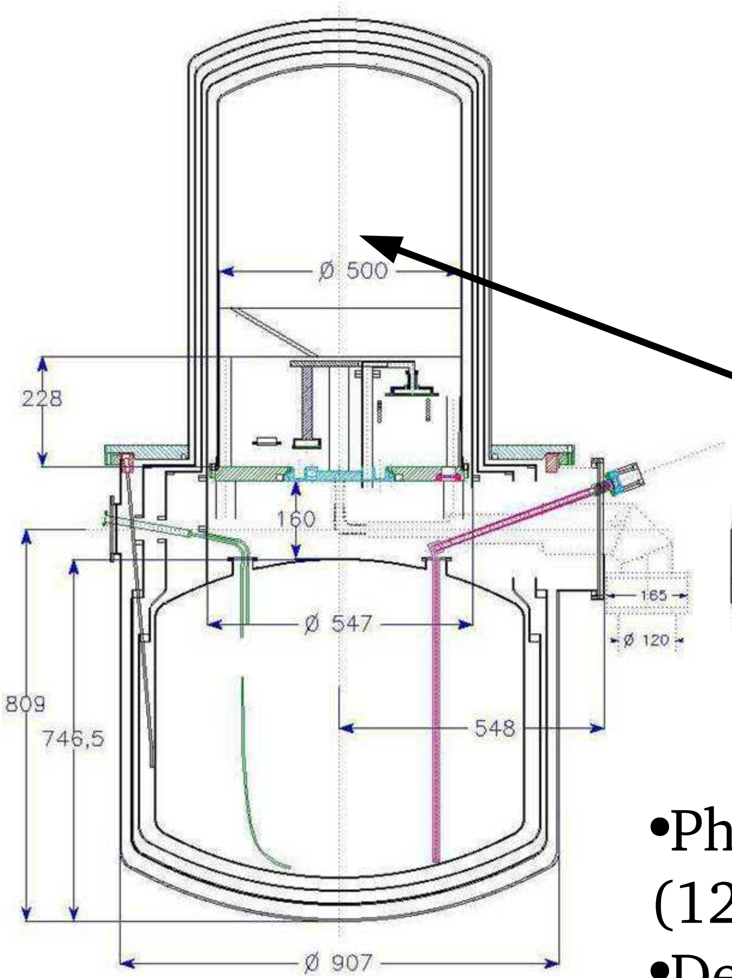
ZEPLIN I (preliminary)

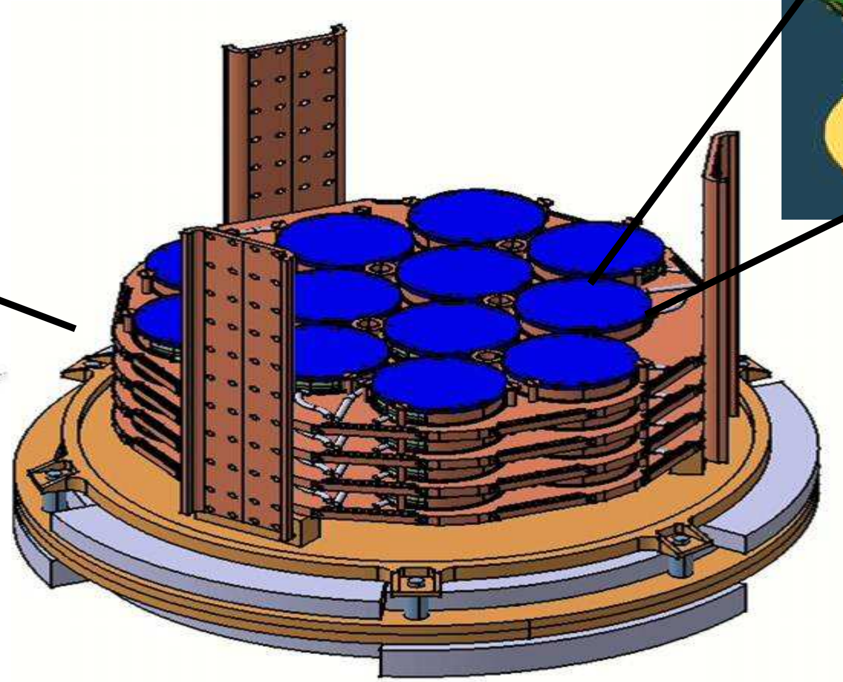
EDELWEISS 2003 no background subtraction

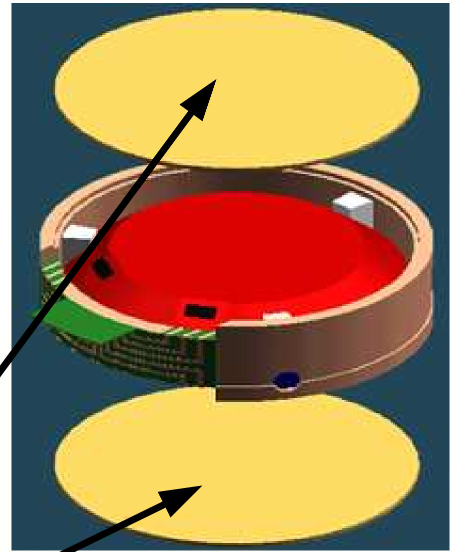
EDELWEISS : what's next

- New run started : improved energy threshold
- Expect further factor > 2 in exposure with improved sensitivity
- September 2003 : EDELWEISS I stops and EDELWEISS II begins with 21×320g Ge-NTD detectors and 7 thin film 200g Ge detectors

Edelweiss II



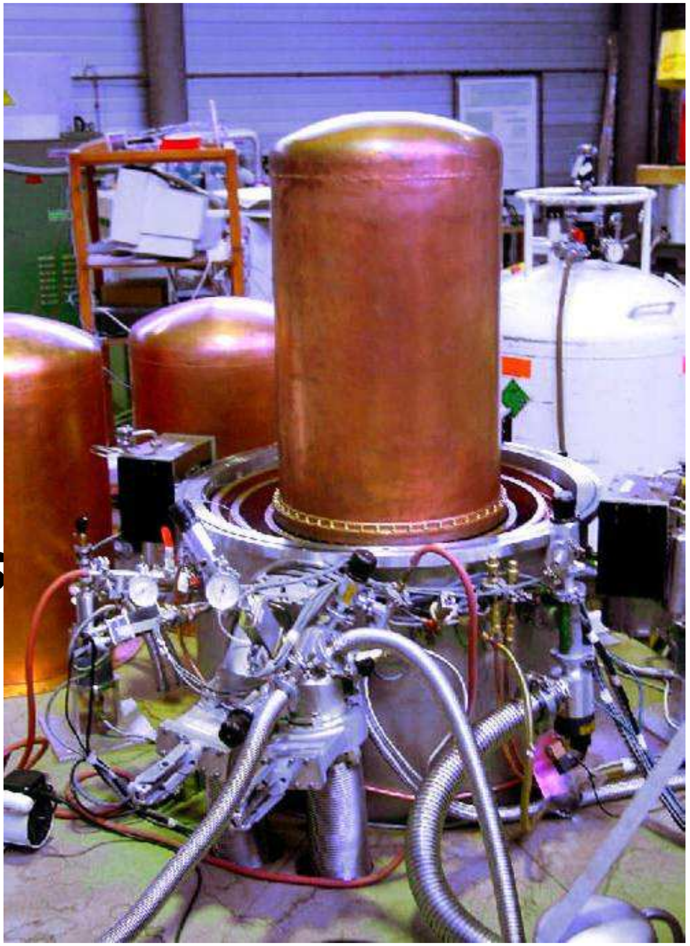




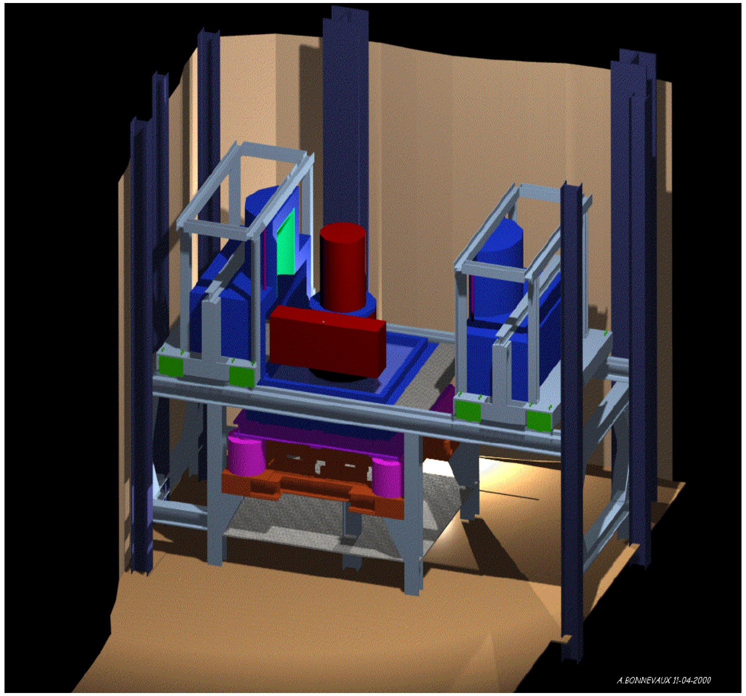
- Phase 28 detectors approved
(120 detectors : ~36 kg Ge)
- Development of NbSi thin film sensors to eliminate surface events

Edelweiss II : New Cryostat

- Larger detector volume ~100 l
- Low radioactivity cryostat
- ~10mK obtained during several runs
- Reverse geometry : more practical for handling detectors and less vibrations
- No nitrogen (no boiling)
- Closed circuit for He



Edelweiss II
Set up:

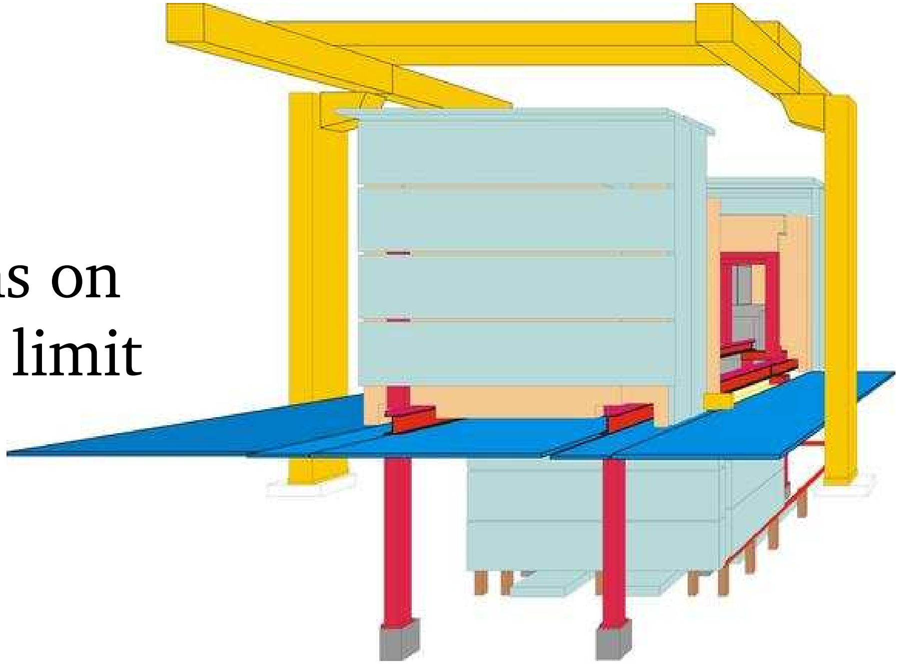


- Sensitivity reached by

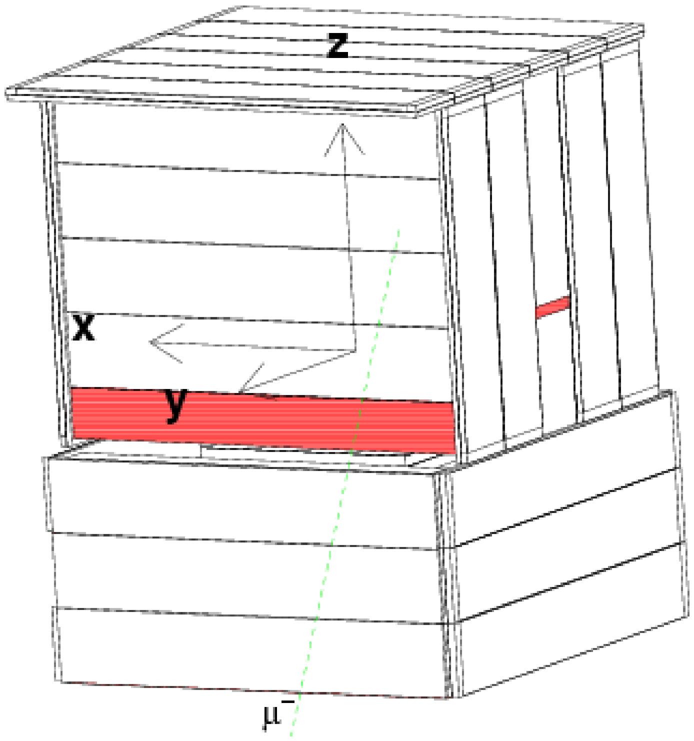
  Edw I : 0.2 evt/kg/d
- Expected sensitivity for

  Edw II : 0.002 evt/kg/d
- Passive shielding

  20 cm Lead +50 cm PE
- Neutron from muon interactions on the rock and inside Edw II may limit the sensitivity => muon veto



Muon Veto

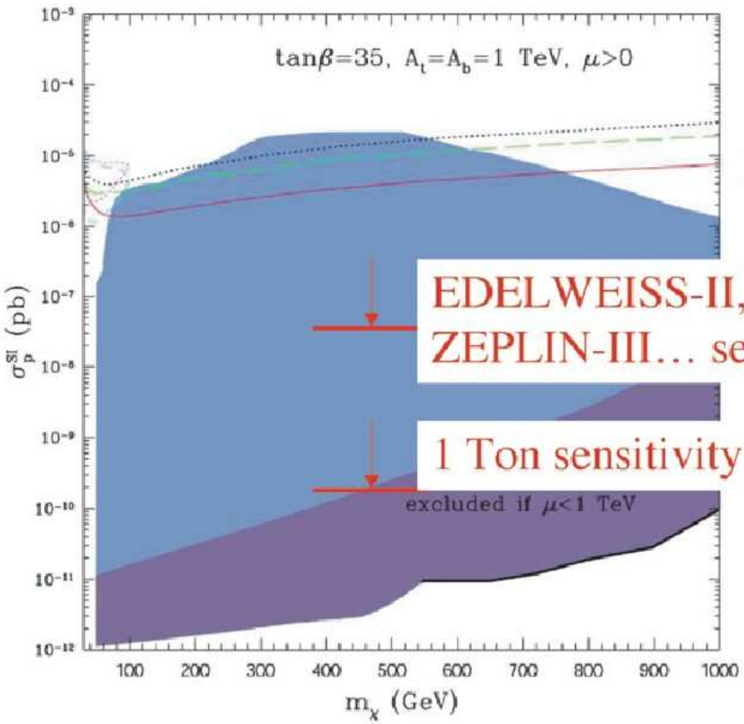


- Made up of ~140 m² plastic scintillators :
  - Built with paddles from KARMEN/Dubna
- Testing the paddles at sea level/LSM :
  - Goal : determine the muon detection threshold
- Simulation of the *geometrical* efficiency:
  - Input : real muon distribution at the LSM

(Frejus Experiment Berger et al., NIM A 262 1987)

- > 99 % at 90 % C.L

Experimental status and theoretical predictions



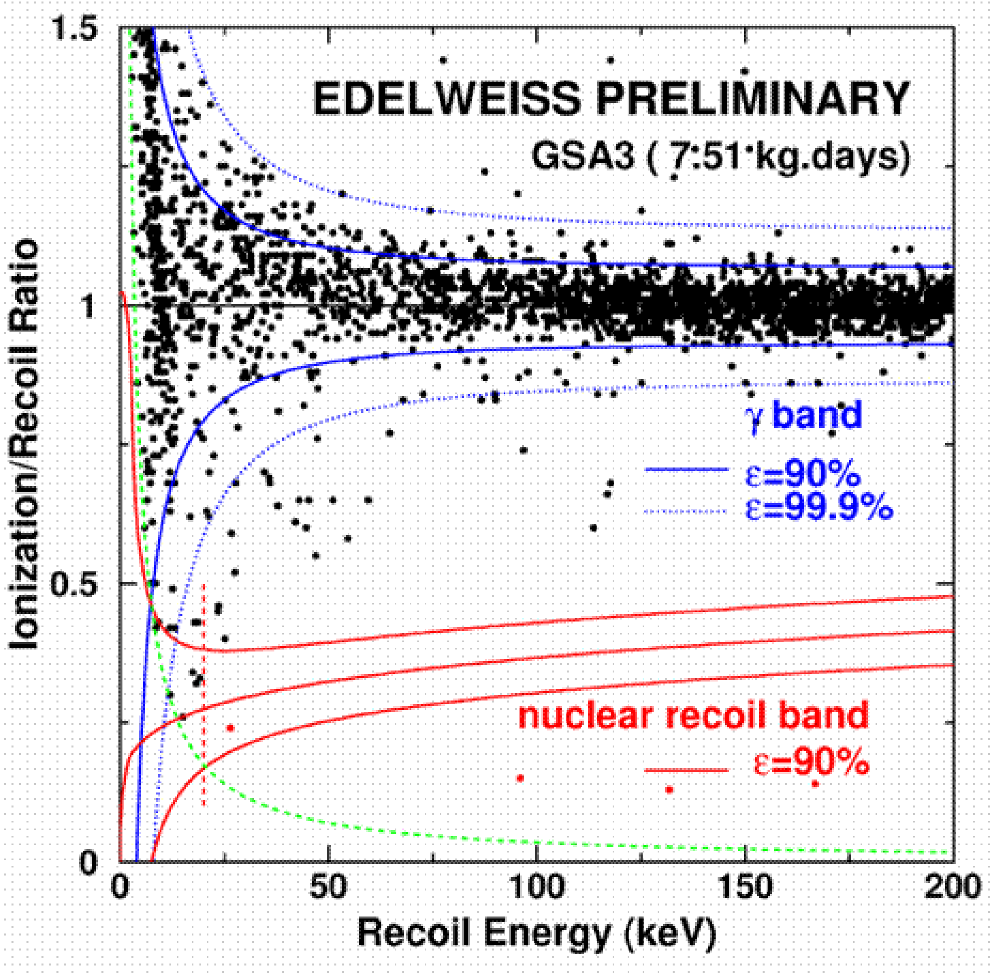
L. Rozkowski et al., hep-ph/0208069

EDELWEISS II => Sensitivity improved by a factor 100

$\longrightarrow \sigma_{SI} \approx 10^{-8} pb$

Bolometer 1 : Q=f(Er) diagram

Events in red (both inside and outside the neutron zone) all arriving within an interval of few day : Instrumental background ?



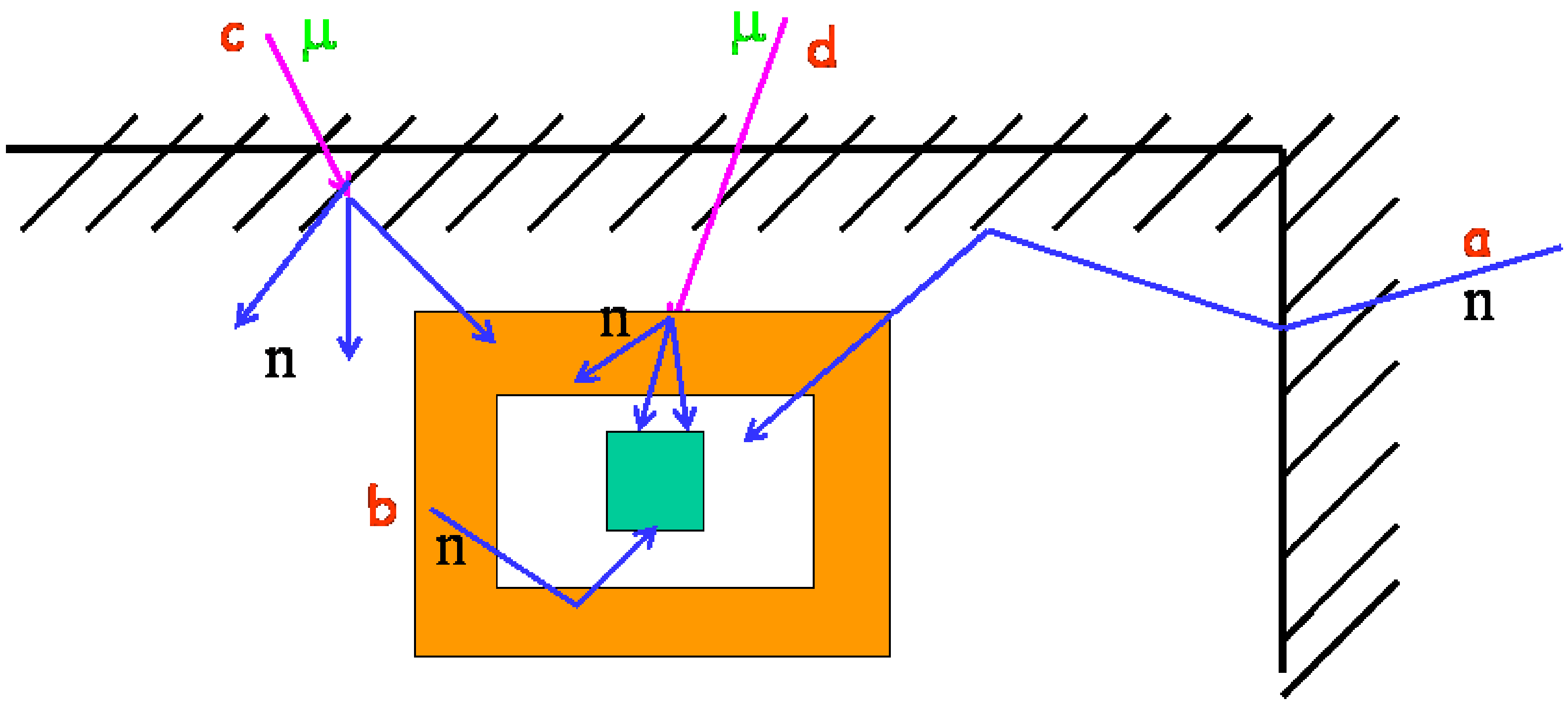
Neutron background sources underground

Low energy neutrons induced by U/Th activities :

- a - in surrounding rock/concrete (fission and (α,n) reactions)
- b - in Pb/Cu Shield (fission reactions)

High energy neutrons induced by muons :

- c - in the rock
- d - in Pb/Cu shield



Measured and expected rates in Ge detectors of Edelweiss-I from neutrons at LSM

Data EDW1-05/01 Pb + Cu only evts/kg/d		Er >30 keV < 2.7
Data EDW1 2001+2002 Pb/Cu + 30cm paraf. evts/kg/d		Er >30 keV < 0.17
Expected rate in EDW 1 Pb + Cu only evts/kg/d	Er >10 keV 3.7	Er >30 keV 1.0
Expected rate in EDW 1 Pb + Cu + 30cm paraf. **evts/kg/d**	Er >10 keV **0.05**	Er >30 keV **0.014**

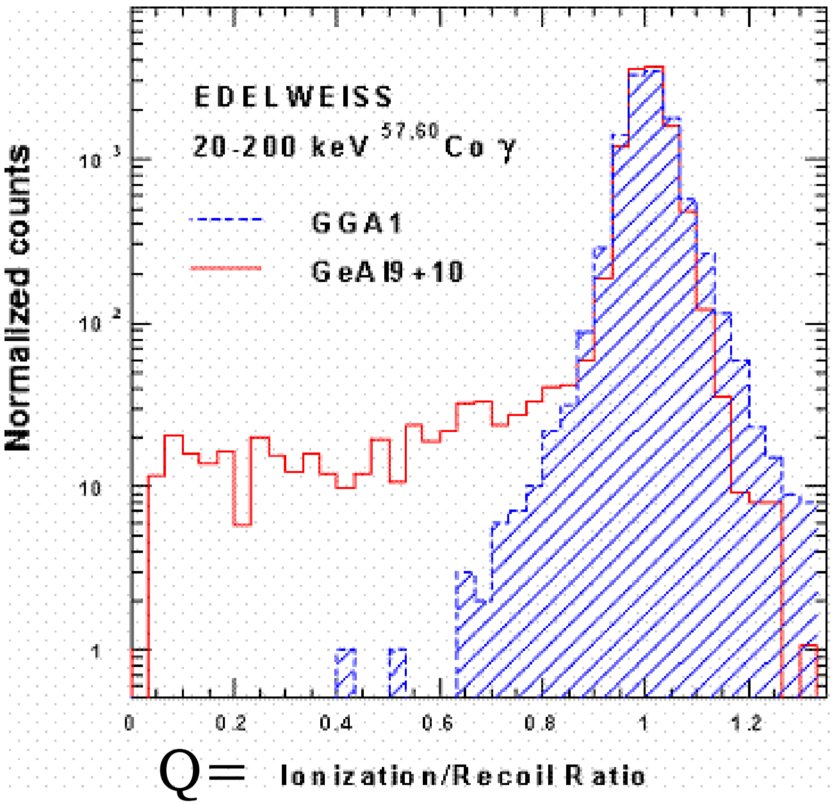
Summary of neutron background flux estimations at EDELWEISS-II detector

Background source	Radioactivity from Rock	U fission in Pb of shield assuming 0.1 ppb	Neutrons from muons in Pb shield	Neutrons from muons in rock
Predicted flux at detector after shield E > 1 MeV	0.4 10^{-10} n/cm^2/sec 1 *≈ 2 milliEdelweiss*	<1.2 10^{-10} n /cm^2/sec <3 *<≈5 milliEdelweiss*	10 10^{-10} n /cm^2/sec 25 *≈ 50 milliEdelweiss*	1.7 10^{-10} n /cm^2/sec 4 *≈ 10 milliEdelweiss*
Predicted flux at detector after shield E > 0.5 MeV	1.2 10^{-10} n /cm^2/sec	<2.4 10^{-10} n/cm^2/sec		3.2 10^{-10} n /cm^2/sec
E spectrum	OK	OK	To check	OK To check

Reminder: 1 Edelweiss ≈ 0.2 event/kg/day at E_{recoil} > 20 keV

Gamma discrimination

- Calibration $^{57,60}Co$
- Region Q<0.5 :
  - 0.01 % for GGA1
  - $\sim$2 % for GeAl
- Amorphous layer effect : charge collection improvement



EDELWEISS I latest results

- Additional 20 kg.d fiducial exposure
- 2 events compatible with nuclear recoils
- Conservatively considered as real events
- Present exposure : 13.8 kg.d @ 20 keV

  30.5 kg.d @ 30 keV
- Incompatibility with DAMA candidate (99.8 %)

  confirmed with 3 different detectors and extended exposure